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An Integrated Approach to Assessing, Managing and Monitoring Campsite Impacts in Warren National Park, Western Australia

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The social and ecological impacts of camping were examined in Warren National Park, Western Australia. The main objective was to apply an integrated approach to assessing campsite degradation and feed this information into a management and monitoring strategy for campsites in the park. Biophysical data were used to establish a campsite profile, providing baseline information that enabled comparison of heavy-use formal campsites with low-use informal campsites. High-use formal campsites were more severely impacted than the low-use, informal campsites. Formal sites were also larger, had experienced more tree damage and erosion, had greater soil compaction, less vegetation cover and tree seedlings, less coarse woody debris, higher riverbank degradation and more walk trails radiating from the campsite. Additionally, the low-use, informal sites had also been degraded by recreation use. Potential indicators were identified, using a social survey that enabled identification of the standards of social and resource conditions in the Warren National Park. Desired conditions were then compared to existing conditions at the campsites and relevant managerial preferences acceptable to visitors were identified in the social survey. Most of the management preferences were considered very or extremely important influences on the quality of the visitor experience.

Introduction

Recreation and tourism have always been important uses of forested areas in Australia. The visitation rate to forested areas in Australia relative to the total population is much higher than Canada or the United States (Westcott, 1993). In Western Australia, recreation and tourism is provided for in both state forest and national parks that are managed to fulfil the demands for recreation which is consistent with conservation of natural values (RFA, 1998). In Australia, recreational activity is often concentrated in relatively small sacrifice zones near road heads and other entrances with access normally gained through the use of cars and off-road vehicles. Activities comprise self-drive touring, visits to day-use sites, picnicking and use of barbecues (BBQs), walking and camping. The provision of permanent camping areas also attracts school groups, people who run outward-bound courses and retreats and organised members of groups such as orienteering, walking, canoeing and four-wheel-drive clubs. Specific sites such as old growth forests, look-out trees that can be climbed, riverbanks and wildflowers are additional focal points of interest, particularly for the nature-based tourism industry.

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Extensive research has been conducted in the US on the impacts of camping and associated recreational activity in wilderness and forested backcountry areas. These studies have reported that camping at various use levels causes: increased soil compaction, loss of ground cover, vegetation damage, change in species composition, destruction of tree production through removal of seedlings, reduction of organic matter, eroded surfaces and tree root exposure (Blakesley & Reese, 1998; Cole, 1983, 1990, 1992, 1995; Kuss *et al.*, 1990; Leung & Marion, 2000; Martin *et al.*, 1989; Trumball *et al.*, 1994). Martin *et al.* (1989) also stated that while these impacts do not threaten the ecological integrity of the entire area, they might result in serious localised resource damage and carry the potential to affect the quality of visitor experience.

Additionally, in Australia the popular practice of day trippers and campers using campfires and wood-supplied BBQs results in the localised loss of coarse woody debris from recreation sites. Thus in areas where campfires are permitted, branches and logs are likely to be removed from a considerable area around the site, greatly enlarging the area affected by camping activities (Liddle, 1997). Such losses are significant because coarse woody debris and standing dead trees play a crucial role in the functioning and productivity of forest ecosystems where they affect soil processes, soil fertility, hydrology, provide shelter for wildlife and habitat for many invertebrates (Bretz Guby & Dobbertin, 1996; Harmon *et al.*, 1986; Hecnar & M'Closkey, 1998).

Since the demand for natural area tourism in Australia is increasing and the area of resource, particularly forested areas, remains largely static, it is important that informed management decisions are made to minimise the impact from increasing recreation and tourism pressure. Because of the limited studies conducted in Western Australia relating to camping it was considered useful to provide an integrated evaluation of the acceptability of impacts, using biophysical and social data. The aims of this paper are therefore (1) to describe current campsite conditions, and (2) to report on visitor opinions about existing impacts and gain visitor perceptions on the future management of these impacts in Warren National Park, Western Australia.

Study Area

Warren National Park is an 'A' class reserve that occupies 3000 ha in the south-west of Western Australia (Figures 1 and 2). The park is dominated by old growth eucalypt forest with the Warren River flowing through it. Karri (*Eucalyptus diversicolor*) and Marri (*Corymbia calophylla*) forests such as those at Warren National Park are internationally recognised tourist attractions due to the presence of endemic species with a limited distribution. Consequently they draw economically significant numbers of visitors to Western Australia. Warren National Park itself receives about 126,000 visitors per annum (CALM unpublished). Activities include: self-drive touring along a well-signposted and promoted scenic drive, appreciating nature, viewing wildlife, walking, picnicking, camping, swimming and fishing. The park has three formal camping areas where use is concentrated and nine informal campsites located within old growth Karri forest adjacent to the Warren River (Figure 2). Other facilities

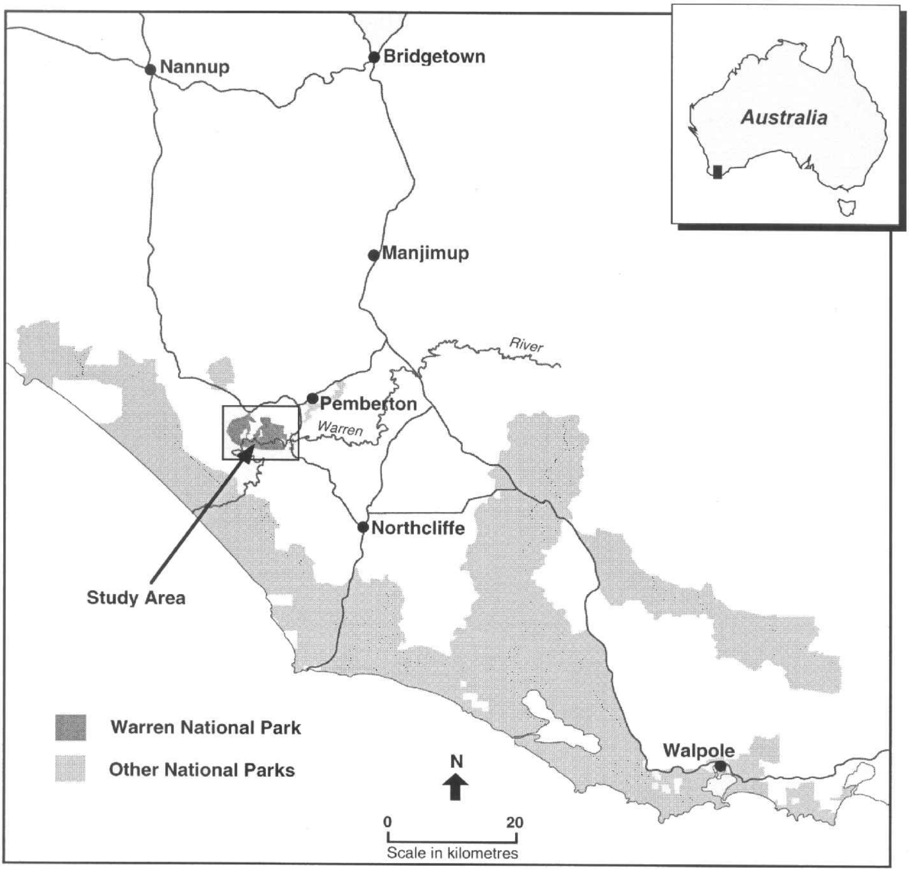

Figure 1 Location map of Warren National Park

within the park include three picnic areas where camping is prohibited, a look-out and numerous walk trails.

The formal camping areas are located along a gravel-surfaced scenic drive accessible in a two-wheel-drive vehicle. Campsites are identified by signs and delineated by boundary markers such as logs placed at the perimeter. Maintenance is provided and fees charged for an overnight stay. Each camp area contains several cleared sites suitable for multiple-party use, car parking facilities surfaced with gravel, multiple fire rings with a steel barbecue plate along with picnic tables and bench seats and a toilet facility located close to the campsite area.

In contrast, informal sites are generally single-party sites accessible by off-road vehicles via fire control management tracks. There is limited site development, with people camping in existing cleared/trampled areas. These sites are user developed, not marked by signs, fees are not charged and limited maintenance is provided. Over time, rudimentary fire rings and log seats have been arranged at these sites that are mostly used when the formal sites are full or when people seek more solitude.

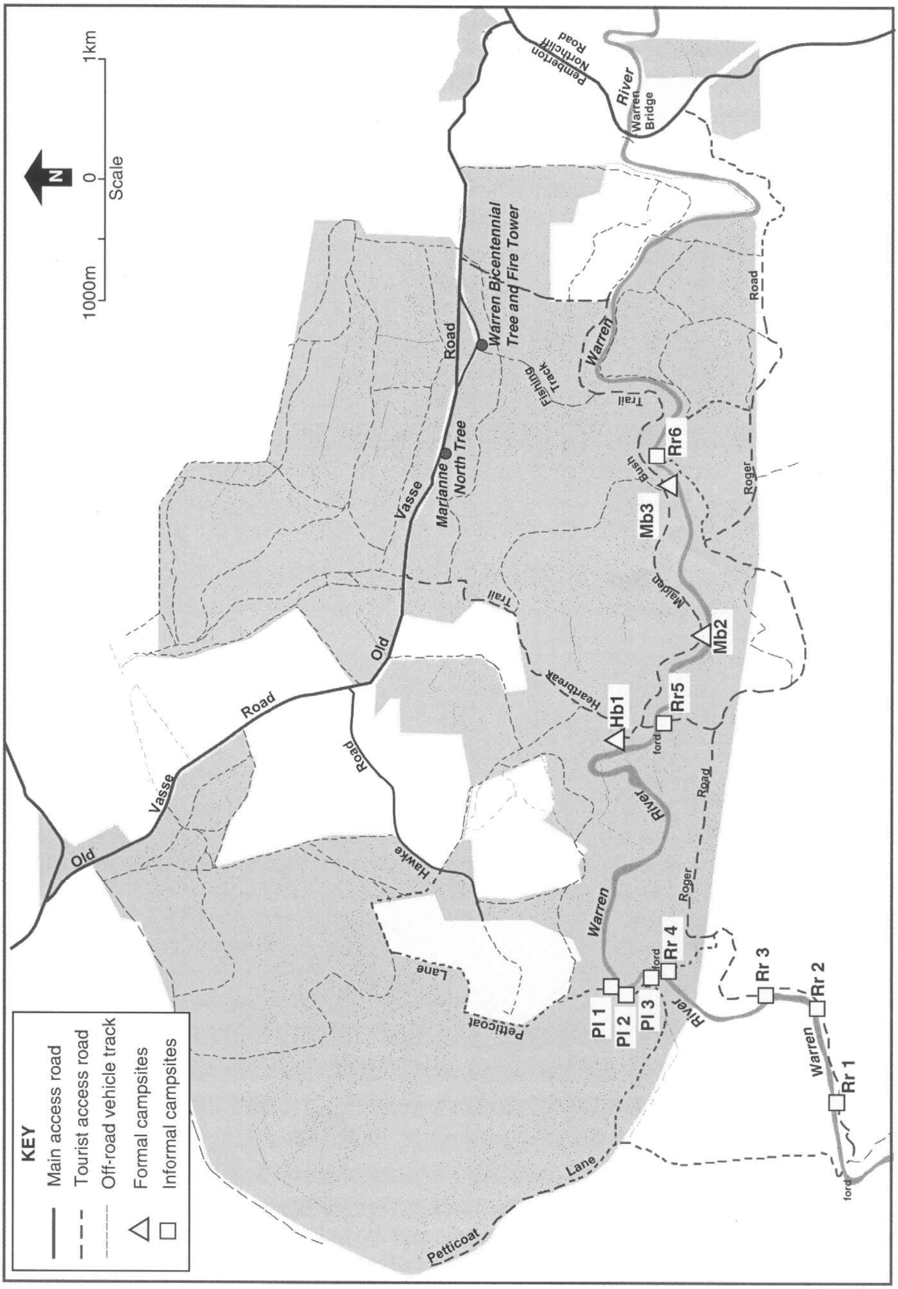

Figure 2 Location map of Warren National Park and key features: the Warren River, formal campsites, informal campsites and picnic sites

Research Methods

Biophysical impacts

Biophysical impacts were measured at all campsites present in the park regardless of whether they were user defined (informal) or formally designated by management (formal). The work was carried out between April and September 1998. Site measurement was based on the fixed radial transect method formulated in the USA by Schreiner and Moorhead (1979), and further refined by Marion (1995) as the variable radial transect method. Soil and vegetation measurements were made using quadrats (15 at each site) located along four predefined linear transects orientated perpendicular to each other at each campsite and an adjacent, similar, undisturbed control site (Cole & Fichtler, 1983). Other information recorded from the quadrats included soil compaction as measured by bulk density and penetrometry, percentage understorey and overstorey cover, and percentage weed versus native species coverage.

A spherical densiometer was used to measure canopy cover at each campsite, the main access point to the riverbank and two randomly placed controls in undisturbed adjacent forest. To determine the extent of firewood collection, methods were adapted from forest fuel sampling methods developed by Van Wagner (1968) and further refined by Smith and Neal (1993). Three survey lines each 25m long and laid out to form an equilateral triangle were placed at selected sites, including formal, informal and control sites. Each piece of wood intercepting the line was recorded and its diameter was allocated to a class size (25–70 mm, 70–300 mm, 300–600 mm and > 600 mm).

Other chosen indicators of impact were human damage to trees, visible signs of erosion such as root exposure, development, cleanliness and social trails. Biophysical data on the condition of walking trails associated with the campsites and nearby riverbanks were also collected. Measurements included trail length, width and depth and visual counts of litter, erosion and exposed roots. For the riverbanks, width and depth of associated river access trails were measured, plus erosion features such as root exposure and bank collapse. Riparian vegetation cover was determined using quadrats in disturbed and similar, undisturbed sites.

Visitor survey

Visitors to Warren National Park (surveyed between April and September 1998) consist of day trippers and variable-stay campers. Day trippers were included in the survey as they use the camping areas as a focal point of activity such as car parking, access to riverbanks and for cooking food on BBQs. Interviewers contacted one member of a visiting group at an individual camping area or recreation site (such as the Bicentennial Tree) and asked that person to fill out a short, 10-minute questionnaire. Most individuals agreed and the questionnaire was then left with the respondent and collected by the interviewer later that day. Questionnaires were also distributed at a café within the park. In this case, one member of a visiting group was approached and asked if he or she had just visited the park. The individual was asked if he or she would like to fill in the questionnaire. The questionnaires were then returned to the interviewer upon completion. This approach was deemed preferable to mail-back surveys because of interest in accurate recall and the desire for a high response rate.

Standards for indicators of campsite condition were sought by asking visitors to give the maximum level of change they would accept. These levels of acceptance were then compared to biophysical measurements to assess their applicability. Questions in the survey addressed visitor perceptions regarding existing environmental conditions and management preferences. A total of 150 surveys were handed out over a three-month period with 117 surveys (combined day trippers and campers) being returned, representing a response rate of 78%.

Results and Discussion

Camping area assessment

Areal measurements

The formal campsites were much larger than the informal campsites with their mean size being 876 m^2 compared to 177 m^2 for the informal campsites (Table 1). In comparison to other studies conducted in natural areas overseas that have similar site conditions to Warren National Park, the formal sites in Warren National Park are much larger whereas the informal sites are of comparable size (Cole & Fichtler, 1983; Cole & Marion, 1988; Marion, 1995). Obua and Harding (1997) found in Kibale National Park, Uganda, that campsites established in 1993 and receiving 5000 campers per year had an average campsite size of 198 m^2. This is comparable to the informal campsite size in Warren National Park. Both Warren National Park and Kibale National Park are accessible to vehicles.

Soil parameters at formal and informal campsites

Both penetration resistance and bulk density were greatest for the centre of the formal campsites. The results show that compaction is much greater at the centre of both the informal and formal campsites in comparison to the control. Soil penetration data show the perimeter of the campsites to be considerably more compacted than the control, with the formal campsites having slightly higher levels of compaction than the informal sites. Over the entire campsite area the penetration resistance typically increased 304% at the formal campsites and 172% at informal campsites as measured against the control site (Table 1). Similarly, various US studies showed penetration resistance increased 71% on campsites in the Bob Marshall Wilderness and 220% in the Boundary Waters Canoe Area (Hammitt & Cole, 1998). Compaction has been shown to decrease the rate at which water infiltrates into the soil (Cole, 1990; McEwen & Cole, 1997). Moreover, water that does not infiltrate into the soil runs off across the surface, increasing the erosion potential, particularly in high rainfall areas such as Warren National Park. This exacerbates existing forms of erosion such as gully erosion, channelling, and root exposure at the riverbank (Table 1). Furthermore, water that does not infiltrate causes relatively flat areas to become saturated, creating boggy areas and increasing the need for excavating trenches around tents.

Table 1 Average amount of change for biophysical parameters on campsites in Warren National Park

	Designated mean (n = 3)	***Informal mean (n = 9)***	***Control mean***
Campsites			
Campsite size (m^2)	876	177	N/A
Tree seedlings (no. of trees)			
Centre of campsite	0	2.5	N/A
Perimeter of campsite	4	16	N/A
Mature trees (no. of trees)			
Centre of campsite	9	2	N/A
Perimeter of campsite	11	4	N/A
Tree damage (no. of trees)	2–8	< 2	0
Root exposure (no. of trees)	2–3	1	0
Level of development (no. of human-made structures)	9.7	0.9	0
Litter	5	6	0
Penetration (kN/cm2)			
Centre	0.26	0.16	0.04
Perimeter	0.07	0.05	0.04
Bulk density (gcm^3) Centre	1.39	1.16	0.77
Vegetation cover (%)	33.4	42.2	85.5
Vegetation loss (%)	61	51	N/A
Weed cover (%)	5	11	0
Native species cover (%)	28	31	85.5
No. of weed species	2	4	0
No. of native species	10	15	14
Firewood collection (No. of contacts per 75 m transect)			
< 70 mm diameter	5	30	72
> 70 mm diameter	4	8	11
Canopy cover (%)	91.3	89.3	98
Riverbank			
Vegetation cover (%)	23.3	54.8	96.9
Weed cover (%)	4	6.7	0
Native species cover (%)	19	48.1	0
Vegetation loss (%)	76	43	N/A
Canopy cover (%)	87.2	86.1	97.8
Width × depth (cm) of river access trail	220.2 × 70.5	96 × 6.1	N/A

Table 2 (*contd)*

	***Designated mean* (n = 3)**	***Informal mean* (n = 9)**	***Control mean***
Length (m) of river access trail	10.85	13.68	N/A
Root exposure (no. of trees)	>8	<2	N/A
Bank collapse	severe	low	nil
Walk trails			
No. of trails radiating from campsite	14	3	N/A
Width × depth (cm) of trail	69.6 × 2.5	48.3 × 0.1	N/A
Length (m) of trail	62.9	38.8	N/A

Understorey vegetation parameters at formal and informal campsites

The average amount of vegetation loss in Warren National Park was 61% at formal campsites and 51% at informal campsites (Table 1). For the formal sites this vegetation loss is substantial due to the larger size of the campsites. On average, the area of vegetation loss at formal campsites is 293 m^2 and at informal campsites the amount of vegetation loss or bare area is 75 m^2. Various studies have found that even in remote wilderness areas, campsites commonly lose most of their vegetation. For example, cover loss in the Eagle Cap Wilderness, Oregon, averaged 87% on high-use sites and 71% on low-use sites (Cole & Fichtler 1983); in Boundary Waters Canoe Area Wilderness, Minnesota, the average loss was 85% (Hammitt & Cole, 1998); and in Delaware Water Gap National Recreation Area, New Jersey and Pennsylvania, the average loss was 89% on high-use sites and 68% on low-use campsites (Cole & Marion, 1988). It could be considered that vegetation loss is inevitable in campsites and various studies have indicated that while relative vegetation cover declines as trampling intensity increases, campsite frequencies as low as one night of use are sufficient to cause evident vegetation impact (Cole, 1995; Cole & Fichtler, 1983).

At the informal campsites in Warren National Park vegetation cover was higher than for formal campsites, with the percentage of weed (non-native) species also being higher (Table 1). Moreover, at least one type of weed species was found on all of the campsites. The most common weed species were *Hypochaeris* sp., *Romulea rosea* and various grass species. These findings at Warren National Park are in accordance with findings in the US. At Boundary Waters Canoe Area Wilderness, for example, it was found that at least one weed species was present at 62% of the surveyed campsites and one campsite had 12 different weed species (Hammitt & Cole, 1998).

It is possible that, because of the lower use levels at informal sites, weed species are able to better establish themselves due to the decreased levels of trampling in comparison to formal campsites. Furthermore, control sites have virtually no weed species present; this may be because of the dense nature of the understorey that on average represented 86% cover and the dense overstorey cover which greatly reduces the opportunity for weed invasion. The presence of weed species in the campsites is probably because weed species such as *Romulea rosea*, *Hypochaeris* sp. and various grass species are more resistant to trampling than native species, which are generally broad-leafed herbs and low growing shrubs with brittle stems. The tolerance of weed species to trampling has been demonstrated in various studies that have examined the impacts of trampling on various types of vegetation (Burden & Randerson, 1972; Cole, 1990; Huxtable, 1987; Liddle, 1997; Sun and Liddle, 1993).

Firewood collection in and around campsites

Even though firewood is provided at formal campsites in Warren National Park and the previous burn time[1] is unknown, the presence of coarse woody debris greater than 70 mm in diameter is low (64% lower) compared to control sites (Table 1). Further, formal sites had on average less than half the amount of coarse woody debris in the 70 mm diameter size than the informal sites where no firewood is provided. The varying fire regimes that can affect the park have probably had less effect on amounts of coarse woody debris greater than 70 mm than collection by visitors, as trends were similar across sites regardless of the previous burn time. The decline in amount of coarse woody debris at formal sites was also repeated for pieces of wood sized less than 70 mm, which is a size that would be considered suitable for breaking by hand and probably used for kindling. The ecological impact of removal of pieces of wood sized smaller than 70 mm is less significant than for larger pieces of wood: however, the collection of wood of any size creates numerous trails through the natural environment and disperses the trampling impact thus increasing the area of disturbance around campsites. In a study conducted by Bratton *et al.* (1978) in the Great Smoky Mountains National Park, the area disturbed by firewood gathering was more than nine times the size of the de-vegetated zone around campsites.

Firewood is currently provided at formal campsites in Warren National Park. It was considered that this action would reduce the impact of firewood collection. Table 1 shows, however, that the opposite was found in this study. To eliminate the need for firewood collection and also remove the need to bring in axes, which some visitors use to damage trees in campsites, it would be preferable that dry firewood is provided in different size classes, including kindling. Minimal impact education may also emphasise the importance of not collecting firewood at formal sites, and encourage users at informal sites to bring firewood with them.

Damage to trees and root exposure

Human damage to trees, such as axe marks and initials, was more prevalent at formal campsites than at informal campsites or on or beside trails. It was found that at formal campsites, a majority of the trees had at least one or two different types of human damage and this level of damage was considered high (2–8 trees damaged) (Table 1). Furthermore, the tolerance for such damage was very low with 82% of visitors indicating that they would only accept 0–5 damaged trees in an area (Table 2). Such results show that for the formal campsites it would appear that the level of tree damage exceeds what visitors find acceptable.

Damage to trees was noted to be severe (>8 trees) at the riverbank of the formal campsites and moderate (2–3 trees) to high (4–8 trees) in the central area of the campsite with root exposure at walk trails and the informal sites being negligible to low (1 tree) (Table 1). Similarly, various US studies have found that tree root exposure was prevalent at campsites and a particularly common occurrence on trails, river and lake banks (Cole, 1983, 1986; Cole & Fichtler 1983). Severe erosion of soils around tree roots can cause mortality and reduce vigour in trees. Furthermore, the presence of trees with severe root exposure is likely to greatly impact on the quality of the visitor experience (Leung & Marion, 2000).

Riverbank condition

The greatest amount of degradation at the riverbank was found at the formal campsites. The river access points could be considered the most severely impacted with evidence of bank scalloping, root exposure, gully development and bank collapse (Table 1). Generally, riverbank access trails at formal campsites were much wider and more deeply incised than for informal, low-use campsites. Furthermore, vegetation cover was greatly reduced at the riverbank of formal campsites. Decreases were indicated for both the understorey vegetation and the overstorey in comparison to controls. The riverbank at formal campsites had on average 76% less cover than the control sites and 60% less cover than the informal campsites. In the undisturbed state, herbaceous perennials such as *Lepidosperma* sp. and ferns such as *Adiantum aethiopicum* and *Pteridium esculentum* generally dominate the understorey vegetation at the riverbank. These species are not tolerant to trampling and therefore would be susceptible to damage in high-use areas. At informal campsites the riparian vegetation was reduced by 43% in comparison to the control; this was, however, often in a small concentrated area at a single river access point. This reduction further emphasises the possible vulnerability of the riparian vegetation at campsites in Warren National Park.

Development of walk trails in the vicinity of campsites

Walk trails radiating from the formal campsites were more numerous and were associated with higher levels of degradation than trails radiating from informal campsites. Walk trails at formal campsites also had a high incidence of lead-off trails mainly going to the river. It is likely that visitors looking for river access to go fishing use these trails. On average, formal campsites had 14 walk trails radiating from the campsite in comparison to only three radiating from informal campsites (Table 1). While many of the walk trails were fairly indistinct (less than one metre wide and generally flat) the level of erosion was only low to moderate at formal campsites and generally low at informal campsites. These results would indicate that while multiple trails are a problem at formal campsites, the general condition of these walk trails could be considered satisfactory.

The visitor survey and its significance in managing campsite impacts

Indicators and standards identified in the social survey allowed the recognition of impacts of concern to visitors. The majority of potential indicators presented to survey respondents were considered 'very/extremely important' to 'moderately important' in contributing to their recreation experience in Warren National Park (Table 2). This suggests that any or all of these represent suitable potential indicators to be used in the management of Warren National Park. Three indicators of importance to visitors in Warren National Park were amount of litter, the presence of wildlife and the number of trees damaged by people. A study conducted in four wilderness areas in the southern US also

Table 2 Biophysical and social factors or conditions influencing the quality of the visitor experience in Warren National Park

Item	*Percentage of respondents*				
	Not at all important	*Not very important*	*Somewhat important*	*Very important*	*Extremely important*
Existing environmental conditions					
The number of trees damaged by people around a campsite and view trails/points (e.g. initials, axe marks, embedded nails)	4	10	20	24	34
The amount of vegetation loss and bare ground around a campsite/picnic area	3	17	25	23	23
Erosion of banks at access points to river	3	13	21	24	20
The number of other groups that camp within sight or sound of my campsite	5	10	27	20	22
The size of other groups camped within sight or sound of my camp	7	9	24	23	18
The number of people camping along the river	7	12	25	21	16
The number of other groups I see along the walk trails	8	34	26	14	9
The presence of wildlife	2	4	11	32	44
The amount of litter	4	1	6	28	53
Number of walk trails	3	8	36	30	16
Width of walk trail (size)	13	23	38	13	5
Condition/quality of walk trails	10	17	38	18	10
Road condition/quality of Heartbreak Trail	8	18	35	18	8
Road condition of Petticoat Lane	12	15	31	8	5
Management preferences					
Daily visits by Conservation & Land Management Ranger	3	10	18	23	25
The presence of cement fire rings	5	8	15	23	28
The presence of pit toilets	4	8	14	28	32
The presence of signs and other human-made structures that I see	6	6	33	20	22
Inadequate disposal of human waste (faecal) at campsites on Roger Road and Petticoat Lane	4	6	15	17	39

found that these three indicators were regarded as important influences on visitor experiences and that the least important influence was number of trail encounters with other groups (Roggenbuck *et al.*, 1993). In accordance with these findings, the least important influence on visitor experience in Warren National Park was the number of other groups encountered along walk trails.

People camping in Warren National Park considered the most important conditions influencing visitor experience were the number of trees damaged by humans, the amount of vegetation loss and erosion of banks at access points to the river. These sorts of characteristics have also been widely chosen as indicators of impacts at campsites in various other studies (e.g. Lucas, 1990; Morin *et al.*, 1997).

While most social conditions were considered moderately important, two social conditions considered important were the number of walk trails and the number of people camping along the river. During peak periods such as Easter, the formal campsites are often full and there is little opportunity for day trippers to enjoy these areas without coming into contact with other people. While other picnicking areas are available, such sites may not be seen as desirable or it may be that they are not as well signposted or as obvious as the formal campsites.

Walk trails within Warren National Park are under various levels of management. For example, those walk trails associated with the Bicentennial Tree may be considered as the most highly managed with signage and trail hardening, while trails associated with campsites are the least managed. The trails at the campsites have mostly evolved by users choosing paths along the riverbank and are not formalised or signposted. Additionally, these campsite trails are not immediately obvious because of obstructed visibility due to the presence of tents. This is a particular problem if the campsite is experiencing constant heavy use, as is the case in peak periods.

Bratton *et al.* (1979) suggested that in high-use areas it is appropriate to concentrate use by hardening trails and increasing the design capacity of walk trails. Over half of the visitors supported improving walk trail condition along the river (Table 3). It would be preferable that some of the existing trails are improved, incorporating low maintenance techniques and ensuring that impacts from increased use are controlled through appropriate trail design, while other trails are closed, thus confining use distribution. It would also be preferable that trails are well signposted and that instructive maps are provided at the main track head as to the location of walk trails, campsites and picnic areas, as supported in the visitor survey.

Visitors indicated that the erosion of banks at access points to the river was an important factor that influenced the quality of their experience. In a study conducted by Madej *et al.* (1994) on the Merced River in Yosemite National Park, California, USA, it was also found that trampling of the banks and riparian vegetation resulting in bank erosion was common and was perceived to be a threat to campsite integrity. Visitors strongly supported providing minimal structures such as stairs and boarding to protect fragile areas. Hammitt and Cole (1998) commented that the provision of boat ramps or hard-surfaced water access reduces erosion and also increases accessibility and public safety. Various other studies have also suggested that setbacks[2] of approximately 30 metres from riverbanks are desirable in heavy-use areas (Newsome *et al.*, 2002). Setbacks

Table 3 Survey respondents' attitudes towards potential management actions for Warren National Park

Potential management action	*Percentage of respondents*				
	Strongly support	*Support*	*Neither support nor oppose*	*Oppose*	*Strongly oppose*
Limit the number of people per group	17	33	27	13	4
Limit use (e.g. type of use, level/ numbers of people entering park)	18	30	22	15	8
Educate users more about minimal impact use and camping techniques	62	28	4	0	0
Discourage use of overused areas	40	37	10	5	1
Temporarily close areas	26	40	15	9	4
Provide signs for direction	34	43	14	5	0
Provide minimal structures such as stairs and boarding to protect fragile areas (e.g. river bank)	38	42	10	4	2
Improve walk trail condition along river	25	40	15	8	1
Improve access road to campsites and picnic areas	12	28	32	18	3
Provide instructive maps of area at main trackhead	31	44	17	2	1
Provide designated camping sites at other areas such as Roger Road and Petticoat Lane	19	38	24	9	3
Rehabilitate sites in Roger Road and Petticoat Lane that have experienced low impact camping use	24	41	20	4	3
Reduce amount of vegetation removal and bare soil in camping areas	31	36	17	3	1
Prevent existing campsites at Heartbreak Trail and Maidenbush trail from expanding in size by containing area	30	38	17	3	1
Relocate campsites away from riverbank, with better design allowing for single party camping and with managed access trails to the river	24	28	23	8	1
Seal Old Vasse Road with bitumen	11	12	26	18	11

would reduce the trampling impact on the riverbank and enable re-vegetation or contribute to the success of rehabilitation, thus assisting in reducing the flow of water across the surface. Increased flow rates increase the rate of erosion of riverbanks. Further, replanting of deep-rooted species in riparian areas helps to stabilise the riverbank and minimise the risk of bank collapse. Setbacks have social value because they decrease the visibility of people camping on the river and assist in preserving the aesthetic qualities that attracted people to the area in the first place (Cole, 1990).

In terms of overall management needs, the majority of Warren National Park survey respondents generally supported all potential management actions (Table 3). Respondents most strongly supported educating users more about minimal impact use and camping techniques, followed by providing minimal structures such as stairs and boarding to protect fragile areas, discouraging use of overused areas, providing signs for direction, providing instructive maps at the main track head and preventing existing areas at formal sites from expanding in size by containing area (Table 3). Management actions that were least supported were sealing the park access road (Old Vasse Road) with bitumen, improving the access road to formal campsites and picnic areas and limiting use (Table 3). Morin *et al*. (1997) reported that the results from the BC Forest Service survey in north-eastern British Columbia also found that respondents most strongly supported educating users more about minimum impact use and rehabilitation of overused areas. The study conducted by Morin (1996) in Nuyts Wilderness Area, Western Australia, also found that management actions similar to those found in Warren National Park were most strongly supported. The support by visitors to Warren National Park for a broad range of management actions provides a wide choice of strategies for managers.

The role of integrated monitoring

Survey respondents were more concerned about biophysical impacts such as the number of trees damaged by people, the amount of vegetation loss and bare ground and erosion than they were about social conditions such as the size and number of other groups encountered whilst in the park. This probably reflects respondents' views that current use levels, although they may be leading to biophysical impacts, are not resulting in a decline in their social experience. The visitor survey conducted by Morin (1996) in Nuyts Wilderness Area, Western Australia, and the study conducted by Roggenbuck *et al*. (1993) in four wilderness areas in the southern US, also found that survey respondents were more concerned about biophysical impacts than social impacts.

Impact indicators, derived from the social survey, provide a set of reference conditions that reflect the degree of naturalness and quality of visitor experiences considered appropriate and acceptable in a natural area. Identifying indicators through social research (Table 2) enables appropriate parameters to be monitored and a database of site conditions to be established. Managers are then able to establish a set of standards based on social and biophysical data that define specific and measurable limits for the selected indicators (Table 2).

Many natural areas around the world are managed for both conservation and recreation. It is, therefore, essential that both social and ecological components be managed in a sustainable manner. In turn, therefore, monitoring is essential in order to preserve ecological values and manage natural areas. Because these areas are also used for recreation it is necessary that an integrated approach is used so that social factors are also considered in combination with biophysical measurements. Social and ecological components are interrelated and integrated monitoring acknowledges the interconnections in both the biophysical and human systems (Margerum, 1999). As already noted, it is essential to managers that information about the ecological and social impacts of recreation are provided, so that informed management decisions are made using a sustainable approach. Integrated monitoring is necessary for areas where no previous studies of monitoring have been conducted, as in this study. Integrated monitoring gives a more holistic approach in a shorter period of time. It involves timely analysis and focused research, which is multidisciplinary in nature (Hicks & Brydges, 1994). Furthermore, it leads to rapid feedback of information, an essential component of effective monitoring.

Conclusion

This study shows that even at low use levels, such as at the informal campsites, recreation leads to changes in resource conditions. The campsite impact profile established in this study and the results from the social survey provide documentation of site-specific conditions and give a permanent and impartial record of current resource and social conditions in Warren National Park.

Such an integrated approach is applicable to other forested areas in Australia and will assist management in making informed decisions regarding the environmental impact of tourism and recreation. It is essential that managers develop long-term management strategies to overcome environmental problems and ensure the sustainability of national parks which also provide for recreation. Management is confronted with the challenge to provide both protection of natural values and provide desirable recreation experiences for users. To do this it is necessary that adequate information on current impacts is provided so that informed decisions are made. Managers need to know how much and what kind of environmental damage is occurring and what conditions visitors consider acceptable. Possible limitations of the survey approach used in this study are an over-representation of day-use visitors and the relatively short period in which the survey was conducted. Despite these limitations, the results from this study enable management efforts to be differentially directed towards indicators of greatest concern.

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Notes

1. Time since last burn which is either a prescribed management burn or wildfire during dry summer period.
2. This involves a restriction on any camping closer than 30 m to the riverbank.

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